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Liquid crystal aligning using different approaches

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Liquid crystal aligning using different approaches

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Abstract. In the current paper the classical and new relief at the interface: solid substrate-liquid crystal mesophase is presented in order to orient the liquid crystal molecules with good advantage. Rubbing technique, some geometric construction at the interface, UV and VIS treatment of the polymers, and laser oriented method are shown. The last one is connected with the materials surface relief modification using the laser-matter interaction process by the application of the IR CO_2–laser at the wavelength of 10.6 micrometers. As the efficient nano-objects applied for the relief improvement the carbon nanotubes with the small refractive index close to 1.1 and the large Young's modulus are used. As an additional, the varied electric field of 100-600 V/cm is applied in order to deposit the carbon nanotubes at the materials surfaces in the vertical position and to form the covalent bonding between the carbon atoms and the model matrix materials surface atoms. The novel results are shown in comparison with that obtained before for the classical orienting liquid crystal molecules methods. It extends dramatically the area of the liquid crystal cells use.

1. Introduction

It is well known that organic nanophotonics problems have stimulated research in designing new methodsfor materials surface modification. Great interest has been expressed in classical liquid crystal (LC) systems, which interface between solid substrate and LC mesophase were constructed with good advantage. Really, as it wasshown before theelectro-optical nematicliquid crystal (LC) is a good model in order to consider the fundamental physical effects in the anisotropic intermediate media [1–5] and to develop the realistic technical devices such as laser radiation switchers, optical limiters for the visible and the near IR-range, convertors, display elements, electrically or optically addressed spatial light modulators, membranes, solar energy cells, etc. technical useful systems [6–11].

The physical-chemical phenomena in LC materials under application of the different external fields, for example, bias voltage connect with the weak intermolecular interaction of the structural elements of LC media with objectives added in the LC mesophase or placed on the interface. Thus, one of the more unique properties of LCs is their orienting ability, which is used to develop new optoelectronic devices based on these LC composites. But, it should be remarked that the relief at the interface: solid substrate-LC mixture influence dramatically on the basic parameters of the LC as well.

SiO_2, SiO, CeO, etc. oxides and polymers (PVA, polyimides, polyvinyl carbozole, etc.) were used via rubbing technique;UV-lamp was applied to irradiate the polymers to use the radical for the LC orientation; holographic grating recording in the VIS and near-infrared, etc. methods [12–15] were applied to create the perspective orienting LC molecules relief. Some views of these reliefs obtained via different approaches indicated above are shown in Fig. 1. In [16–19] a method of formation of a periodic microrelief on the surface of polymer substrates with solid coating for liquid crystal alignment and different optical applications is described and reviewed.

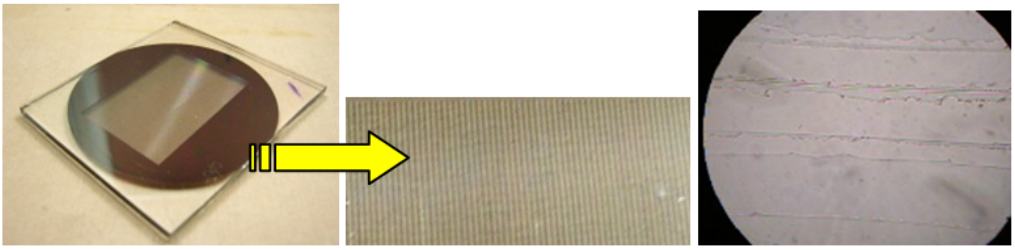

Figure 1. Relief with grating of 10, 20 and 40 micrometers can be developed using holographic recording method (a); relief creating via application of the rubbing technique (b)

In the current paper the accent is given on use of the unique method connected with the laser oriented deposition (LOD) techniqueuse and surface electromagnetic waves (SEWs) treatment of the interface between solid substrate and LC.

2. Experiments conditions

IR CO_2–laser with -polarized irradiation at a wavelength of 10.6 micrometers operating with the power of 30W was used. This technique is titled as laser oriented deposition (LOD) method. As the efficient nano-objects applied for the relief improvement the carbon nanotubes (CNTs) with the small refractive index close to 1.1 and the large Young's modulus are used to modify the relief at the interface: solid substrate with ITO coating-LC mesophase.Moreover,the electric field of 600 V/cm is applied in order to deposit the carbon nanotubes at the mentioned above interface in the vertical position and to form the covalent bonding between the carbon atoms and the model matrix materials surface.The main steps of this procedure and block scheme have been shown in Ref.19 and paper [20] respectively. It should be notices that the singlewall carbonnanotubes (SWCNT, type ♯ 704121, with varied diameters of 0.7-1.1 nm) were purchased from Aldrich Co.The special accent has been given to observe the relief at the material surface via checking of the wetting angle. In this case, the OCA 15EC device purchased from LabTech Co. (Saint-Petersburg-Moscow, Russia) was applied. Furthermore, the novel materials, namely glassy carbon, has been treated with SEW as well. The SEW treatment has been made at the center of the flat surface.

The modified surfaces were controlled via Solver Next AFM (purchased from NTI Co., Zelenograd, Moscow, Russia) in the contactless mode. Some evidence to form the novel perspective relief is shown in Fig. 2. One can see the surfaces images obtained for the pure ITO layer (Fig. 2, a), modified ITO (Fig. 2, b) and two figures connected with the picture of the glassy carbon sample and the glassy carbon surface treated with the surface electromagnetic waves in the indicated direction to reveal the relief (Fig. 2, c).

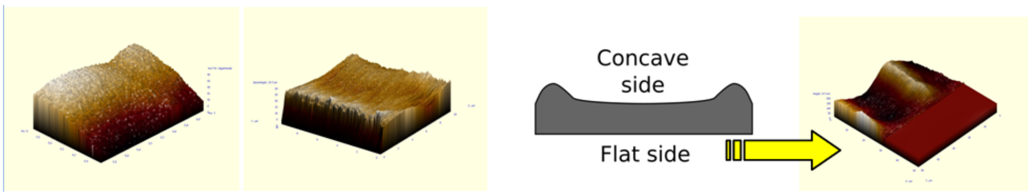

Figure 2. Relief obtained for the pure ITO (a); relief creating via application of the laser oriented deposition technique and SEW treatment (b); the picture of the glassy carbon structure with different two sides and relief revealed at the glassy carbon materials treated with SEW (c)

3. Results and discussion

It is important to note that we have taken into account the evidences to organize the covalent bonding between CNTs atoms and near interface ITO atoms. The quantum-chemical simulation supported this bonding formation has been made in the Ref. [21]. Moreover, supporting experimental results have been received via study of the resistivity, mechanical hardness and laser strength as well as via the measurement of the wetting angle. These experiments revealed the dramatic decrease of the resistivity, increase mechanical and laser strength and the wetting angle as well. Some results based on the resistivity change for the 7 samples are shown in the diagram presented in Fig. 3.

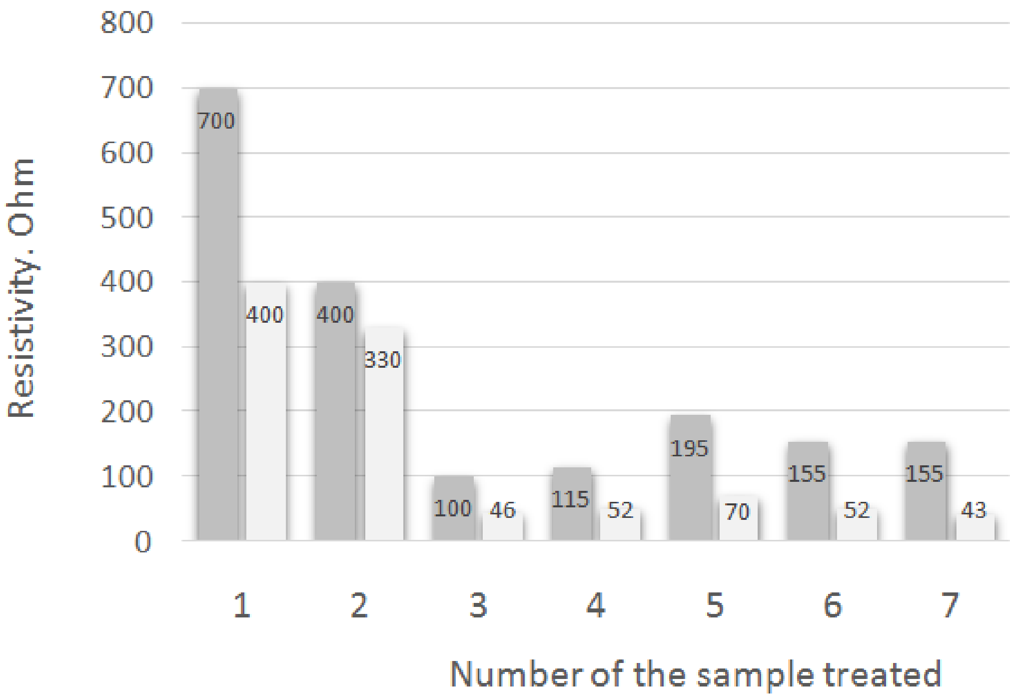

Figure 3. Resistivity shown for pure ITO (dark grey); relief creating via application of the laser oriented deposition technique (slight grey)

Thus, analyzing the data shown in Fig. 3 one can testify that the nanostructurization of the ITO layers with CNTs dramatically influence on the resistivity. As the results, the applied voltage can be decrease efficiently.

Furthermore, the change of the wetting angle have been found, which are shown in Fig. 4. One should added that the same tendency of the wetting angle increasing via application of the LOD approach and CNTs placement has been found for the KBr materials as well [22].

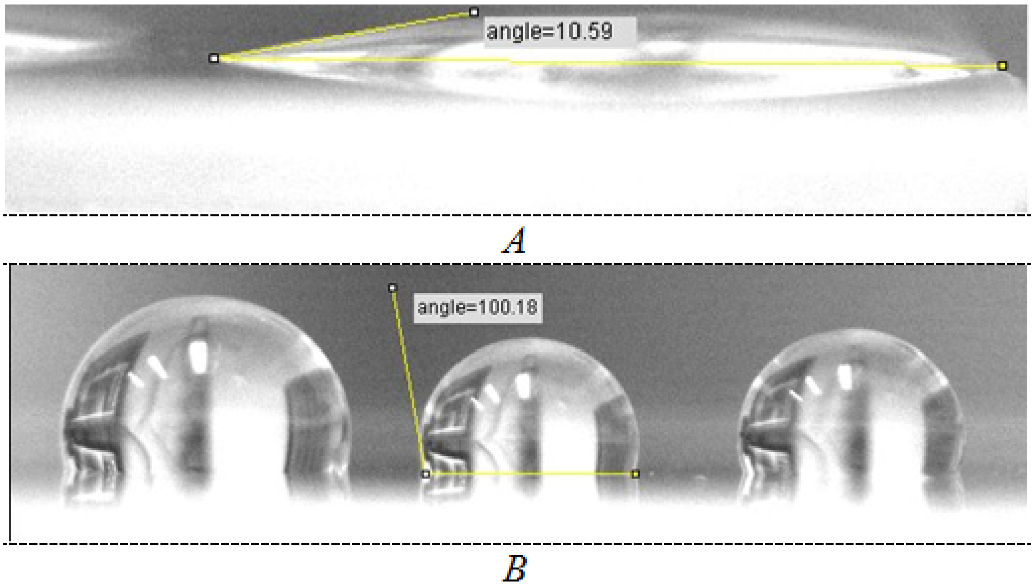

Figure 4. Wetting angle for the pure ITO and the glass substrate (a); wetting angle for the ITO+CNTs vertically deposited at the material surface (b)

Analyzing the data of Figs. 2-4 one can testify that the application of the CNTs vertically placed via laser oriented deposited method at the interface: solid substrate with ITO conducting layer-LC mesophase predicts and supports the perspective alignment approach to orient the LC molecular. Moreover, this approach can be considered in comparison with the famous known MWVA technique. Regarding the dramatic decrease of the resistivity (please see Fig. 3) one can predict that the large number of the electron from the core of the CNTs can change the conductivity of the ITO coatings that provokes the change of their resistivity efficiently.

4. Conclusion

The comparative results of the classical and new relief at the interface: solid substrate-LC mesophase have been shown. The basic consideration has been made on the shortly analysing of the ITO coatings treated with the LOD technique via placement of the CNTs in the vertical position. Change of the topology of the relief and resistivity as well as the wetting angle has been shown. Dramatic influence of the additional electron from the core of the CNTs has been predicted that provokes the decrease of the resistivity. Discussed relief can be useful for the LC molecular orientation with good advantage. As an additional remark, it should be noticed that the system based on the glassy carbon should be detailed study in future in order to use it in the LC technology.

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